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Selecting Sprinkler Packages for Center Pivots

Design for center pivot systems involves a complex array of physical and economic considerations. A well designed system will ensure that:

1. discharge capacity matches the consumptive use requirements of the crop, plus normal application losses
2. water is uniformly applied
3. the application rate of the system does not exceed the intake rate of the soil
4. droplet sizes are acceptable
5. total energy input is minimized
6. the end gun is sized properly

A summary of typical sprinkler packages used in Alberta is show in Figure 1 (page 2).

System capacity

The consumptive use requirement is the amount of water required by the crop to satisfy the evapotranspiration process to maintain optimum growth and production. Not only must the amount applied be correct but the timing must coincide with plant demands. Pivot discharge then, is selected by taking into account specific crop, soil and climatic conditions.

System capacity must be combined with adequate operator management to meet crop water use demands through peak periods. Oversizing system capacity to decrease operating hours or to mitigate the consequences of poor management is wasteful of energy and may result in undesirable application rates. Undersizing system capacity to reduce capital or energy costs often results in undesirable crop yield losses. Professional advice in selecting capacity to be compatible with crop use and other limitations is always recommended.

Application uniformity

Uniformity of application has been traditionally expressed in terms of UC (uniformity co-efficient) where 100 per cent would theoretically be ideal. Typically 90 to 95 per cent can be expected if the system is operated under ideal conditions. Under field conditions the two variables having the most detrimental effect on uniformity are wind and pressure fluctuations. Wind distorts the sprinkler pattern, reduces the radius of throw and causes loss of water by drift and evaporation.

Pressure fluctuations result in discharge variation which may cause poor uniformity of application. The two common pressure problems are field elevation changes and pressure fluctuation at the pivot point. These pressure fluctuations tend to have a greater detrimental affect on low pressure sprinklers. Pressure problems can be effectively controlled by use of pressure regulators or flow control devices on all or part of the sprinklers, depending on the particular package selected.

Application rates and droplet size

It is possible to have excellent system uniformity and yet poor field uniformity. This occurs if the water is applied faster than the soil can absorb it. The resulting standing water or runoff will be reflected in poor field uniformity.

By the nature of a pivot's circular travel the sprinklers have to apply progressively larger amounts of water toward the outer end of the pivot lateral. As a result, instantaneous application rates at the outer end become very high. Depending upon the selection of impact sprinklers of spray heads, the instantaneous rate will vary from approximately 1 in./hr to 6 in./hr respectively. Although the rate that water is being applied can be very high, the fact that the system continually moves means that the soil is exposed to the water for a relatively short period of time. This "soak time" is also affected by the width of the coverage pattern or throw radius. This soak time can vary from 15 to 100 minutes for pivots with typical capacities.

Pivots equipped with wide spacing (sometimes referred to as constant spacing) and high pressure sprinklers have a coverage width of approximately 150 feet near the end of the pivot and thus provide the longest "soak" time of any available option. Systems having widely spaced sprinklers must be operated at high pressures to provide adequate overlap coverage and droplet coverage. For these high pressure packages low angle sprinklers are better in wind. Narrow spacings to 12 feet at end of pivot) sometimes referred to as variable spacing have a coverage band of approximately 110 feet with a medium soak time. Because there are many more sprinkler nozzles on the variable spacing, it is possible to achieve smaller droplets at lower operation pressures than with the wide spacing. Spray heads have a narrow coverage band of approximately 25 feet near the last tower and have the highest instantaneous application rate and the shortest soak time. High pressures should

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END GUN ANGLE (SEE FIG. 2)	END VIEW (NOT TO SCALE)	OUTLET SPACING	NOMINAL MIN PSI (AT OUTER SPRINKLERS)	TYPICAL SPRINKLER TYPE AND TRAJECTORY ANGLE	RELATIVE DROPLET SIZE	APPLICATION RATE	UNIFORMITY (NO-WIND)	COMMENTS
B	STANDARD ANGLE SPRINKLER 130'- 170' (WIDE) 100'- 130' (VARIABLE)	WIDE (CONSTANT) 32'- 40' (MAX)	45 - 85	23°- 27°		LOWEST	VERY GOOD	MAX. COVERAGE WIDTH TO PROVIDE LOWEST APPLICATION RATE. BEST OPTION FOR LOW INTAKE RATE SOILS AND HIGH CAPACITY SYSTEMS. REQUIRES HIGHER PRESSURE WHICH REDUCES VARIATIONS UNDER MEDIUM ROLLING TERRAIN. CLOSE VARIABLE SPACINGS PROVIDES LARGE POPULATION OF FINE DROPS WHICH HELPS TO PREVENT SOIL CRUSTING BUT INCREASES SPRAY LOSSES IN WINDY CONDITIONS.
		CLOSE (VARIABLE) 30'/20'/10'/5'	30 - 50	23°		MED - LOW	EXCELLENT	
A	LOW ANGLE SPRINKLER 120'- 150' (WIDE) 85'- 110' (VARIABLE)	WIDE (CONSTANT) 24'- 32' (MAX)	40 - 60	6°- 12°		LOW	VERY GOOD	EXCELLENT OPTION FOR HIGH WIND CONDITIONS. PRESSURE OPTION CAN BE USED ON MEDIUM INTAKE SOILS ON MODERATELY ROLLING TOPOGRAPHY.
		CLOSE (VARIABLE) 30'/20'/10'/8'	30 - 50	6°- 12°		MEDIUM	EXCELLENT	
C	SPRAY NOZZLE/ROTATOR ON TOP 40'- 50' (SPRAY) 70'- 90' (ROTATOR)	5'- 10'	15 - 30	360° SPRAY — USE CONCAVE PAD		HIGH	GOOD	SUBJECT TO WIND DRIFT. REQUIRES MODERATELY HIGH INTAKE SOILS AND RELATIVELY FLAT TOPOGRAPHY. PRESSURE REGULATORS RECOMMENDED WHERE FIELD ELEVATION CHANGES MORE THAN 10 FEET. FLOW CONTROL NOZZLES POSSIBLE WITH ROTATOR OVER 25 PSI.
		8'- 10'	15 - 50	USE U4 ROTATOR PLATE		HIGH	GOOD	
C	SPRAY NOZZLE/ROTATOR ON DROP 25'- 40' (SPRAY) 50'- 70' (ROTATOR)	5'- 10'	10 - 25	360° SPRAY — CONCAVE PAD OR FLAT PAD OR CONVEX PAD		VERY HIGH	GOOD - FAIR	SPRAY NOZZLES SHOULD BE USED ONLY ON SANDIER SOILS WITH HIGH INTAKE RATES AND FLAT TOPOGRAPHY. PRESSURE REGULATORS REQUIRED WHEN ELEVATION CHANGE IS MORE THAN 10 FEET. ROTATOR MAY BE USED ON HEAVIER SOILS AND GRADUAL SLOPES. FLOW CONTROL NOZZLES POSSIBLE WITH ROTATOR OVER 25 PSI.
		5'- 10'	10 - 50	10 - 15 PSI USE D8 PLATE 15 - 50 PSI USE D4 PLATE		HIGH	GOOD	
C	SPRAY NOZZLES ON DROP BOOMS 50'- 75'	BOOM EVERY 16' TO 30' WITH 3 TO 7 SPRAY NOZZLES PER BOOM	12 - 25	FOR 0 - 3' ABOVE CROP USE CONCAVE PAD 360° SPRAY — 3'- 7' USE FLAT PAD CONVEX PAD FOR OVER 7' ABOVE CROP		MED-HIGH	VERY GOOD-GOOD	BOOM ANGULAR ALIGNMENT VERY CRITICAL FOR GOOD UNIFORMITY. WIDER COVERAGE BAND ALLOWS USE ON FINER SOILS AND ROUGHER TOPOGRAPHY THAN SINGLE SPRAY HEADS.

FIG. 1 SPRINKLER PACKAGES FOR CENTER PIVOTS

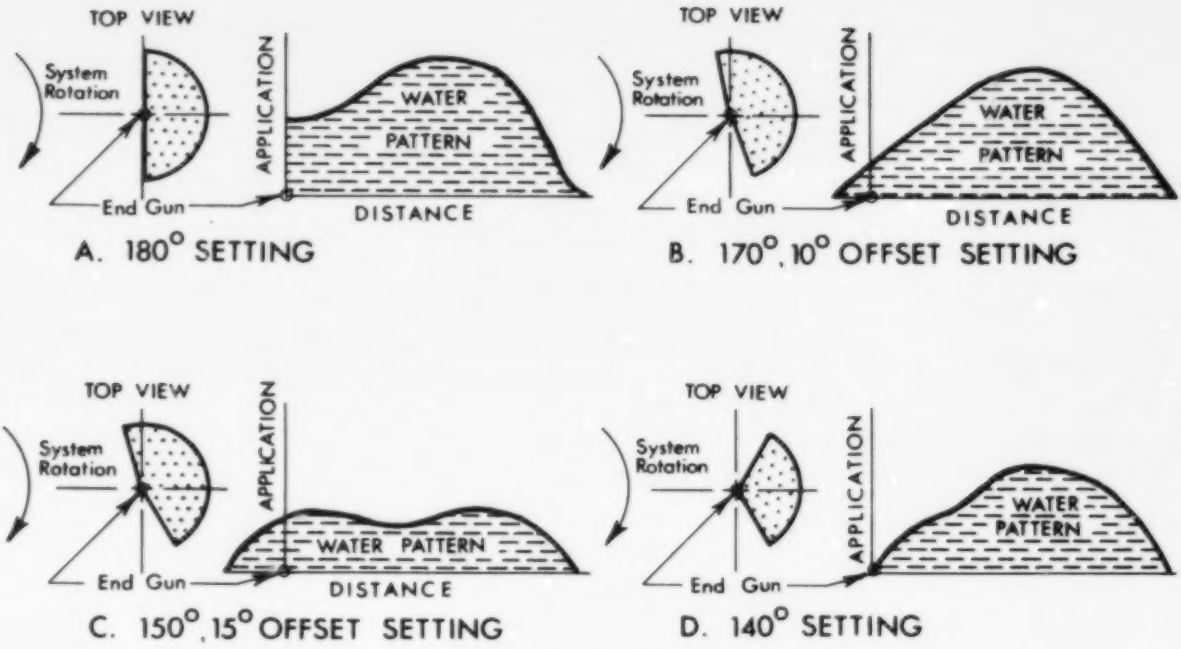

FIGURE 2 END GUN SETTING

be avoided with these as there will be high losses from wind drift. If properly designed, the spray nozzle has the finest droplets.

There is a very complex relationship between system capacity, droplet size, the width of the coverage band and those soil characteristics which determine the ability of the soil to accept the water being applied. It is virtually impossible to make generalized recommendations as only experience dictates the best sprinkler option for various soil conditions. Generally the best chance of getting water into low intake rate soils is to provide the finest droplets and the widest coverage band, which is usually difficult to achieve.

Poor water infiltration can also be caused by poor soil tilth, presence of sodium salts and other minerals, surface sealing or excessive slope conditions.

Energy considerations

It is obvious that it is in the best interest of the farmer to achieve all water application objectives while minimizing pivot pressure in order to conserve energy and thereby reduce costs. Caution must be used when selecting low pressure merely for the sake of reducing energy requirements.

Low pressure can potentially result in larger droplets, excessively high application rates, poorer uniformity or lower application efficiency. This is particularly important on fine texture soils, steep slopes or where there are fluctuating pressures. There is the possibility of lowering crop production, thereby negating any energy cost savings, if any of the above problems exist.

End gun selection

The end gun on a typical "quarter-section" size center pivot represents approximately 8 per cent of the area irrigated and 14 per cent of the total system capacity. In addition to proper adjustment it is very important to operate end guns at the proper pressure. This usually require the use of a booster pump for the end gun when the main system utilizes a low pressure sprinkler package.

Generally, setting the angle as shown in Figure 2 will give the best uniformity, taking into account the sprinkler packages shown in Figure 1. It should be noted that methods B and C will result in some water being thrown back toward the pivot from the end gun. This may be undesirable if there is a large sprinkler located near the end gun. Since the specifics for setting for most uniform coverage varies with the spacing and type of sprinklers used near the end of the system, the center pivot manufacturer's recommendations should be followed.

Center pivot and sprinkler manufacturers have provided a wide range of options to meet individual farm conditions. It is recommended that the irrigator obtain the best technical advice available in this design process.

More information can be obtained by contacting your nearest irrigation specialist. They are located at Taber, Brooks, Vauxhall, Bow Island, Medicine Hat, Strathmore, Airdrie and Lethbridge.

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